AJR FOCUS ON:

Hip Anatomic Variants That May Mimic Abnormalities at MRI: Labral Variants

Mike S. Nguyen[1]
Valeriy Kheyfits[1]
Brian D. Giordano[2]
Gregory Dieudonne[1]
Johnny U. V. Monu[1]

OBJECTIVE. Normal anatomic variants of the acetabular labrum are observed on MR images and include labral variants, several sublabral sulci, and perilabral sulcus. Because variants can be misidentified as labral abnormalities such as labral tears, the radiologist needs to avoid the pitfall of mistaking variants as abnormalities.

CONCLUSION. The hip has multiple anatomic variants that can mimic abnormalities at hip MRI. The labrum has several anatomic variants that can be confused with true labral tears.

The hip is a ball-and-socket synovial joint formed by the articulation of the femoral head with the acetabulum. The acetabulum covers 170° of the femoral head. The acetabular labrum is a fibrocartilaginous structure like the glenoid labrum, and it is shaped to outline the acetabular socket. The acetabular labrum is composed mostly of thick, type I collagen fiber bundles organized predominately in parallel to the acetabular rim with scattered bundles oblique to the parallel bundles [1]. The acetabular labrum attaches to the margins of the acetabular rim and deepens the acetabular socket as much as 21%. By deepening the joint, the acetabular labrum promotes hip stability and guards against femoral head translation.

The acetabular labrum functions as a shock absorber, joint lubricator, and pressure distributor. By increasing the surface area of the acetabulum 28%, the acetabular labrum helps to distribute load [2]. Furthermore, the acetabular labrum works as a seal to keep the synovial fluid within the articular cartilage and maintain fluid pressure [3, 4]. Even surgically repaired acetabular labrums are not as effective fluid seals as a normal intact labrum [5]. By distributing the load and maintaining the seal, the acetabular labrum decreases contact stress on articular surfaces and prevents direct contact between the femoral head and the acetabular articular cartilage. Without the labrum, the articular cartilage can be subjected to increases in contact stress as great as 92%, leading to hip instability and early joint degeneration [3].

The acetabular labrum is poorly vascularized. The blood supply is mostly peripheral. The outer third of the acetabular base of the acetabular labrum is vascularized, and the rest is avascular [6]. Therefore, the acetabular labrum has limited ability to repair itself if damaged.

Numerous studies have been conducted to investigate MRI of the asymptomatic hip, the acetabular labrum in particular. Investigators have identified many anatomic variants, including labral variants, several sublabral sulci, perilabral sulcus, transverse ligament–labral junction sulcus, and anterosuperior cleft. These variants can be confused with labral abnormalities. Most notably, several of the sublabral sulci can be mistaken for labral tears. The purpose of this article is to describe these labral variants and highlight the key differences between them and true labral abnormalities.

Labral Variability

The acetabular labrum exhibits variability in shape, symmetry, and MR signal intensity. The most common labral shape is triangular and occurs in 66–69% of asymptomatic hips. Round (11–16%) and flat (9–13%) configurations are less common [7, 8]. A small percentage of patients (3%) do not have a labrum [7]. The labrum varies 2–3 mm in thickness [9]. It is thickest in the superior and posterior aspects and widest in the anterior and superior aspects of the hip [2]. Labral shape becomes more variable with advancing age. The incidence of triangular labrum decreases markedly with age, but the incidence of rounded and irregular margins increases [8, 10, 11]. When both hips in a patient without symptoms are compared, the labral shapes may differ as much as 15% and the sizes as much as 25% [7].

Keywords: acetabulum, hip, labral tear, MRI, sulcus, variant

DOI:10.2214/AJR.12.9860

Received August 31, 2012; accepted after revision February 25, 2013.

[1]Department of Imaging Sciences, University of Rochester Medical Center, 601 Elmwood Ave, Box 648, Rochester, NY 14642. Address correspondence to V. Kheyfits (valeriy_kheyfits@urmc.rochester.edu).

[2]Department of Orthopaedics, Division of Sports Medicine, University of Rochester Medical Center, Rochester, NY.

CME/SAM
This article is available for CME/SAM credit.

WEB
This is a web exclusive article.

AJR 2013; 201:W394–W400

0361–803X/13/2013–W394

TABLE 1: Classification Systems of the Acetabular Labrum

System and Stage	Characteristics
Czerny	Based on MR arthrographic findings
IA	Hyperintense signal with no communication with articular surface; perilabral sulcus
IB	IA without perilabral sulcus
IIA	Contrast extension into articular surface; perilabral sulcus
IIB	IIA without perilabral sulcus
IIIA	Labral detachment; perilabral sulcus
IIIB	IIIA without perilabral sulcus
Lage	Focused on etiologic and morphologic features; poor correlation with MRI findings

Variability in MRI signal intensity is also seen in the acetabular labrum [7, 8, 10, 12, 13]. In 44–56% of asymptomatic hips, the labrum has low signal intensity in all MR sequences. Other MR signal variations include intermediate signal intensity on T1-weighted and proton density–weighted images (58%), intermediate signal intensity on T2-weighted images (37%), and high signal intensity on T2-weighted images (15%). The internal signal variation is more common in the superior and anterior aspects of the labrum. The internal signal intensity may appear globular, linear, or curvilinear and may extend to the labral margins. The incidence of internal signal in general and of internal signal that extends to the labral margins increases with age. Therefore, the task of differentiating a normal labrum that contains internal signal that may extend to the labral margins from an abnormal labrum can be difficult and may require intraarticular administration of gadolinium contrast medium.

Labral Tears

Because of improvements in MRI and arthroscopic techniques, acetabular labral tears are being diagnosed with increasing frequency [4]. In patients with hip or groin pain, the prevalence of labral tears is a reported 22–55%. More than 90% of patients with diagnosed labral tears report anterior hip or groin pain and less frequently pain in the lateral region or deep in the posterior buttocks [14, 15]. Mechanical symptoms include painful clicking, transient locking or catching, and the hip's giving way. Clicking is the most consistent symptom. Labral tears can contribute to hip instability by compromising the seal that maintains synovial fluid pressure. At least five causes of labral tears have been proposed: trauma, femoroacetabular impingement, capsular laxity and hip hypermobility, dysplasia, and degeneration [16].

Labral tears occur either when the labrum detaches from the adjacent acetabulum or when the labral substance intrinsically tears. Labral tears are unstable on probing during arthroscopy. At MRI, detachments are visualized as discrete fluid-filled or contrast-filled clefts extending partially or fully through the labral substance, whereas intrasubstance tears are characterized as irregularities of the labrum itself [17] (Fig. 1). Labral detachments are more common than intrasubstance tears, but both may occur concurrently in the same labrum.

Perilabral abnormalities are associated with labral tears. These include chondral lesions and perilabral cysts. McCarthy et al. [14] reported that 73% of patients who had fraying or labral tears also had chondral damage that was also more severe than if no labral lesion had been present. In 94% of cases the chondral damage occurred in the same acetabular region as the labral lesion. The relative risk of serious chondral damage approximately doubles if a labral lesion is present. Younger patients more commonly had isolated labral tears, whereas older patients had a labral tear in conjunction with chondral lesions. This suggests that the labral tear may have preceded and led to the chondral damage.

For a diagnosis of labral tear to be made, the acetabular labrum must be adequately visualized, which cannot be accomplished consistently with CT or MRI alone [18]. MR arthrography (MRA) has higher sensitivity and specificity than MRI alone because intraarticular gadolinium contrast material is used to distend the joint and outline any tears. Czerny et al. [13] found that the sensitivity and accuracy of MRI alone in the diagnosis of labral tears were 30% and 36% but increased to 90% and 91% for MRA. Compared with arthroscopy, however, MRA has 60–100% sensitivity and 44–100% specificity [19]. Hence, arthroscopy remains the reference standard for diagnosing labral tears.

Czerny et al. [20] developed a staging system for labral tears based on MRA findings (Table 1). This staging system is used primarily to evaluate the presence of intrasubstance contrast and the perilabral sulcus. However, the Czerny staging system does not correlate well with the arthroscopic staging system developed by Lage et al. [21]. Blankenbaker et al. [17] have attempted to bridge the Czerny and Lage classification systems. The Blankenbaker system uses a clock face to describe the location of acetabular labral findings (Fig. 2). By convention, the 3-o'clock position is anterior, the 9-o'clock position posterior, 12-o'clock position superior, and 6-o'clock position inferior, regardless of the laterality of the acetabulum.

Differentiating Sulcus From Labral Tear

A sulcus forms where the labrum meets the adjacent articular cartilage. Several sulci can be identified in the asymptomatic hip, including several sublabral sulci, a transverse ligament–labral junction sulcus, and a perilabral sulcus, and should be considered normal anatomic variants. Figure 3 shows the key differences between a sulcus and a labral tear.

At MRI, sulci can be differentiated from labral tears by appearance, location, and perilabral abnormalities. Sulci have smooth labral edges, whereas labral tears tend to have irregular edges. Most labral abnormalities are found in the anterior and anterosuperior aspects of the acetabulum; the posterosuperior and anteroinferior aspects are less common locations [19]. Posteroinferior labral abnormalities are rare. Posterior labral tears—due to posterior hip dislocation or dysplasia—are more commonly seen in younger patients [22]. Sulci such as sublabral sulci can be found in all anatomic positions. Perilabral abnormalities such as chondral lesions and perilabral cysts are associated with labral tears and not with sulci.

Sublabral Sulci

Sublabral sulci are present in as many as 25% of patients and can be found in all anatomic positions. The most common positions are posterosuperior (48%) and anterosuperior (44%), and the less common are anteroinferior (4%) and posteroinferior (4%) [23]. An anterior sublabral sulcus is most likely to be confused with an anterior labral tear (Figs. 4 and 5). Similarly, a posterior sublabral sulcus is most likely to be confused for a posterior labral tear (Figs. 6 and 7). Because most labral tears have an anterior location, it is particularly important to be able to differentiate an anterior sublabral sulcus from a labral tear. Studler et al. [24] identified features of anterior sub-

labral sulci that could be used to differentiate them from labral tears. An anterior sublabral sulcus is usually located at the 4-o'clock position; has linear morphologic features; exhibits partial separation of the labrum; and has no perilabral abnormalities, such as cartilage lesions, osseous abnormalities, or ganglion cysts. In their study, Studler et al. used the 9-o'clock position as anterior and noted that the anterior sublabral sulcus was most commonly found at the 8-o'clock position, which corresponds to the 4-o'clock position if the 3-o'clock position is used as anterior as proposed by Blankenbaker et al. [17].

Transverse Ligament–Labral Junction Sulcus

The transverse ligament bridges the acetabular notch at the inferomedial acetabulum and joins the two ends of the acetabular labrum, forming a complete ring [25]. A normal sulcus can be seen in the anterior and posterior aspects where the transverse ligament intersects with the acetabular labrum (Fig. 8). The sulcus can be seen at the anterior labral–ligamentous junction in 33% of hips and can be mistaken for an anterior labral tear or traumatic anteroinferior labral–ligamentous detachment [26, 27]. To differentiate it from most anterior labral tears, the sulcus is typically located more inferiorly than would be expected for a labral tear. In addition, an adjacent periligamentous recess anteromedial to the ligamentum teres is often seen with this normal sulcus.

Perilabral Sulcus

At the anterior and posterior margins, the hip joint capsule inserts directly at the base of the labrum. On coronal images, the anatomic space created between the joint capsule and labrum is the perilabral sulcus (Fig. 9). Because the joint capsule inserts several millimeters above the labrum, the sulcus is larger in the superior as opposed to the anterior or posterior aspect [25, 28]. Joint fluid trapped within the perilabral recess can mimic a perilabral cyst, which could suggest a labral tear [26]. By distending the joint space, MRA can help to differentiate between joint fluid and a perilabral cyst.

Anterosuperior Cleft

The anterosuperior cleft is seen as a partial extension of fluid into the undersurface of the anterior labrum on coronal and sagittal images [25] (Fig. 10). It may be more commonly seen in labral hypertrophy associated with mild developmental dysplasia of the hip.

Summary

MRI of the hip may show normal anatomic variants of the labrum. The variants can be of the labrum itself or associated with the labrum. These anatomic variants can easily be mistaken for pathologic findings on MR images. The radiologist needs to be able to differentiate these variants from true abnormalities, such as labral tears. Awareness of these anatomic variants should reduce the frequency of unnecessary workups, patient anxiety, and overtreatment.

References

1. Narvani AA, Tsiridis E, Tai CC, Thomas P. Acetabular labrum and its tears. *Br J Sports Med* 2003; 37:207–211
2. Tan V, Seldes RM, Katz MA, Freedhand AM, Klimkiewicz JJ, Fitzgerald RH Jr. Contribution of acetabular labrum to articulating surface area and femoral head coverage in adult hip joints: an anatomic study in cadavera. *Am J Orthop* 2001; 30:809–812
3. Ferguson SJ, Bryant JT, Ganz R, Ito K. The acetabular labrum seal: a poroelastic finite element model. *Clin Biomech (Bristol, Avon)* 2000; 15:463–468
4. Robertson WJ, Kadrmas WR, Kelly BT. Arthroscopic management of labral tears in the hip: a systematic review of the literature. *Clin Orthop Relat Res* 2007; 455:88–92
5. Cadet ER, Chan AK, Vorys GC, Gardner T, Yin B. Investigation of the preservation of the fluid seal effect in the repaired, partially resected, and reconstructed acetabular labrum in a cadaveric hip model. *Am J Sports Med* 2012; 40:2218–2223
6. Seldes RM, Tan V, Hunt J, Katz M, Winiarsky R, Fitzgerald RH. Jr Anatomy, histologic features, and vascularity of the adult acetabular labrum. *Clin Orthop Relat Res* 2001; 232–240
7. Aydingöz U, Oztürk MH. MR imaging of the acetabular labrum: a comparative study of both hips in 180 asymptomatic volunteers. *Eur Radiol* 2001; 11:567–574
8. Lecouvet FE, Vande Berg BC, Malghem J, et al. MR imaging of the acetabular labrum: variations in 200 asymptomatic hips. *AJR* 1996; 167:1025–1028
9. Bharam S. Labral tears, extra-articular injuries, and hip arthroscopy in the athlete. *Clin Sports Med* 2006; 25:279–292
10. Abe I, Harada Y, Oinuma K, et al. Acetabular labrum: abnormal findings at MR imaging in asymptomatic hips. *Radiology* 2000; 216:576–581
11. Petersilge CA, Haque MA, Petersilge WJ, Lewin JS, Lieberman JM, Buly R. Acetabular labral tears: evaluation with MR arthrography. *Radiology* 1996; 200:231–235
12. Cotten A, Boutry N, Demondion X, et al. Acetabular labrum: MRI in asymptomatic volunteers. *J Comput Assist Tomogr* 1998; 22:1–7
13. Czerny C, Hofmann S, Neuhold A, et al. Lesions of the acetabular labrum: accuracy of MR imaging and MR arthrography in detection and staging. *Radiology* 1996; 200:225–230
14. McCarthy JC, Noble PC, Schuck MR, Wright J, Lee J. The Otto E. Aufranc Award: the role of labral lesions to development of early degenerative hip disease. *Clin Orthop Relat Res* 2001; 25–37
15. Narvani AA, Tsiridis E, Kendall S, Chaudhuri R, Thomas P. A preliminary report on prevalence of acetabular labrum tears in sports patients with groin pain. *Knee Surg Sports Traumatol Arthrosc* 2003; 11:403–408
16. Kelly BT, Weiland DE, Schenker ML, Philippon MJ. Arthroscopic labral repair in the hip: surgical technique and review of the literature. *Arthroscopy* 2005; 21:1496–1504
17. Blankenbaker DG, De Smet AA, Keene JS, Fine JP. Classification and localization of acetabular labral tears. *Skeletal Radiol* 2007; 36:391–397
18. Lewis CL, Sahrmann SA. Acetabular labral tears. *Phys Ther* 2006; 86:110–121
19. Groh MM, Herrera J. A comprehensive review of hip labral tears. *Curr Rev Musculoskelet Med* 2009; 2:105–117
20. Czerny C, Hofmann S, Urban M, et al. MR arthrography of the adult acetabular capsular-labral complex: correlation with surgery and anatomy. *AJR* 1999; 173:345–349
21. Lage LA, Patel JV, Villar RN. The acetabular labral tear: an arthroscopic classification. *Arthroscopy* 1996; 12:269–272
22. Ikeda T, Awaya G, Suzuki S, Okada Y, Tada H. Torn acetabular labrum in young patients: arthroscopic diagnosis and management. *J Bone Joint Surg Br* 1988; 70:13–16
23. Saddik D, Troupis J, Tirman P, O'Donnell J, Howells R. Prevalence and location of acetabular sublabral sulci at hip arthroscopy with retrospective MRI review. *AJR* 2006; 187:[web]W507–W511
24. Studler U, Kalberer F, Leunig M, et al. MR arthrography of the hip: differentiation between an anterior sublabral recess as a normal variant and a labral tear. *Radiology* 2008; 249:947–954
25. Stoller DW, Sampson TG, Li, AE, Bredella MA. The hip. In: Stoller DW, eds. *Magnetic resonance imaging in orthopaedics and sports medicine*, 3rd ed. Philadelphia, PA: Lippincott Williams and Wilkins, 2007:41–304
26. DuBois DF, Omar IM. MR imaging of the hip: normal anatomic variants and imaging pitfalls. *Magn Reson Imaging Clin N Am* 2010; 18:663–674
27. Dinauer PA, Murphy KP, Carroll JF. Sublabral sulcus at the posteroinferior acetabulum: a potential pitfall in MR arthrography diagnosis of acetabular labral tears. *AJR* 2004; 183:1745–1753
28. Petersilge CA. MR arthrography for evaluation of the acetabular labrum. *Skeletal Radiol* 2001; 30:423–430

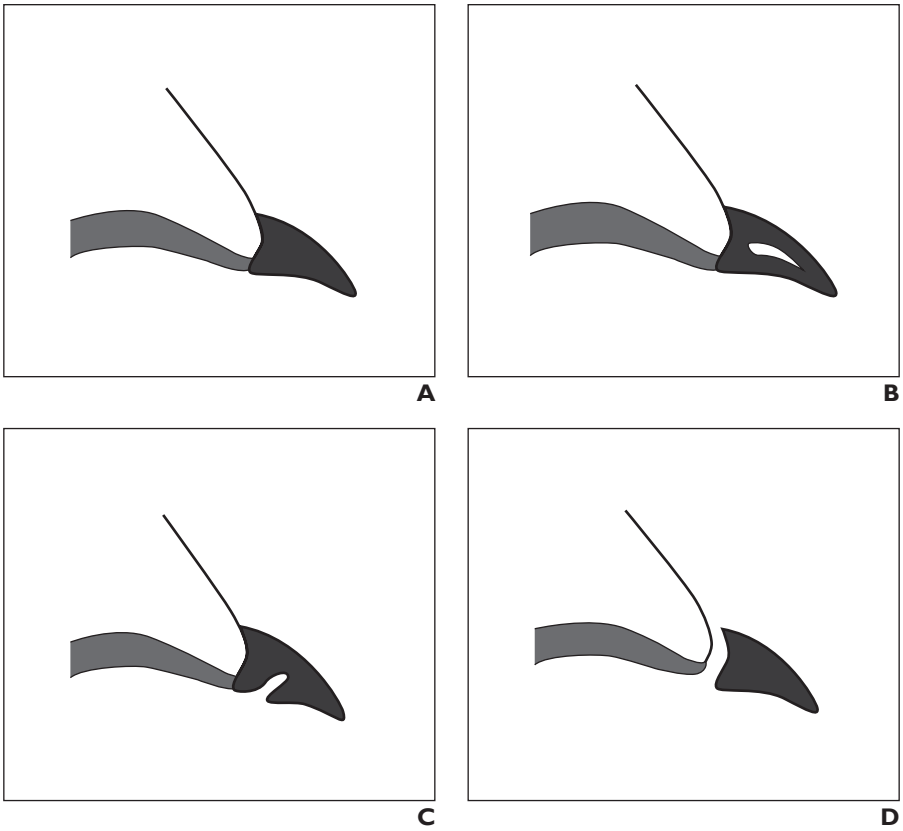


Fig. 1—Schematics show labral tears. Adapted with permission from [13]. Illustration copyright University of Rochester.
A, Normal labrum.
B, Intrasubstance labral tear.
C, Partial-thickness labral tear.
D, Full-thickness labral tear.

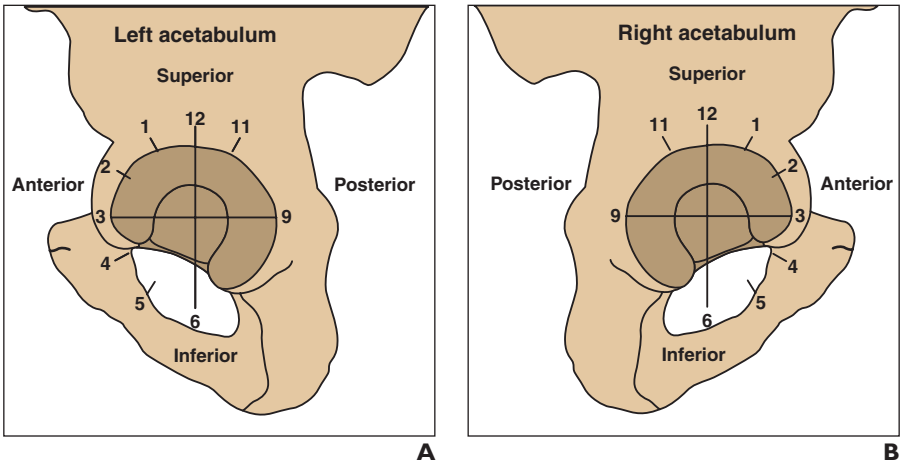


Fig. 2—Blankenbaker clock face of labral tears. Illustration copyright University of Rochester.
A and **B,** Drawings show how Blankenbaker system uses clock face to describe location of acetabular findings. By convention, 3-o'clock position is anterior; 9 o'clock, posterior; 12 o'clock, superior; and 6 o'clock, inferior. Clock positions are same whether left (**A**) or right (**B**) acetabulum is used.

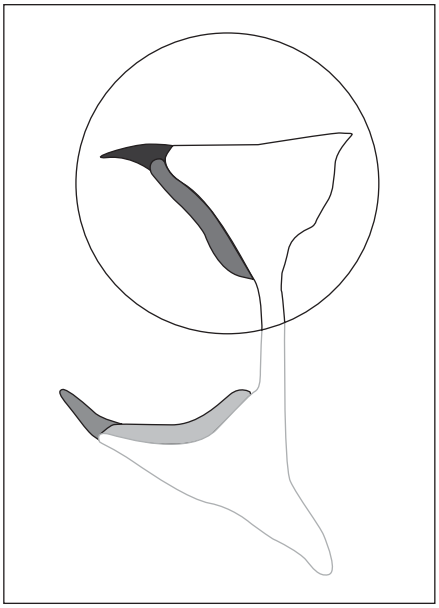
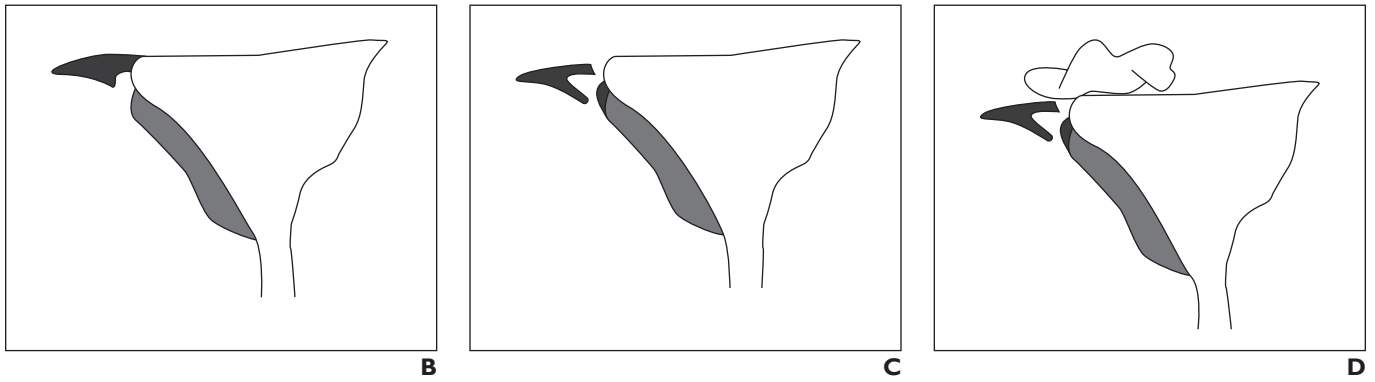


Fig. 3—Schematics show differentiation of sulcus from labral tear. Illustrations copyright University of Rochester.
A, Normal acetabular labrum.
B, Sulcus forms where labrum meets adjacent articular cartilage.
C, Labral tear occurs either when labrum detaches from adjacent acetabulum or when labral substance intrinsically tears.
D, Perilabral abnormalities such as perilabral cysts are associated with labral tears and may be only clue to underlying labral abnormalities.



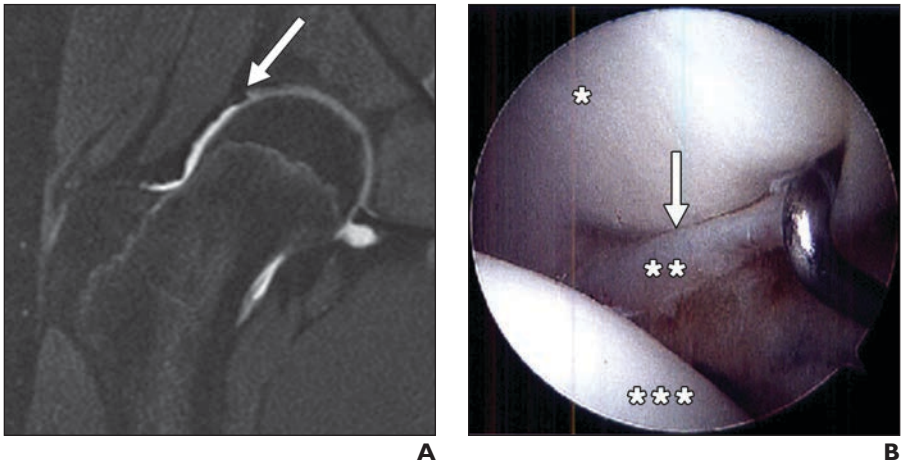


Fig. 4—13-year-old boy with anterosuperior sublabral sulcus.
A and **B,** Coronal fat-saturated intermediate-weighted MR (**A**) and arthroscopic (**B**) images show anterosuperior sublabral sulcus (*arrow*), acetabulum (*single asterisk,* **B**), labrum (*double asterisks,* **B**), and femoral head (*triple asterisks,* **B**). Anterosuperior location is second most common for sublabral sulcus. These sulci can be confused with anterior labral tears.

Fig. 5—27-year-old woman with anterior labral tear.
A–C, Axial (**A**) and coronal (**B**) fat-saturated intermediate-weighted MR arthrographic and arthroscopic (**C**) images show anterior labral tear (*arrow*), acetabulum (*single asterisk,* **C**), labrum (*double asterisks,* **C**), and femoral head (*triple asterisks,* **C**). These findings can be confused with anterior sublabral sulci.

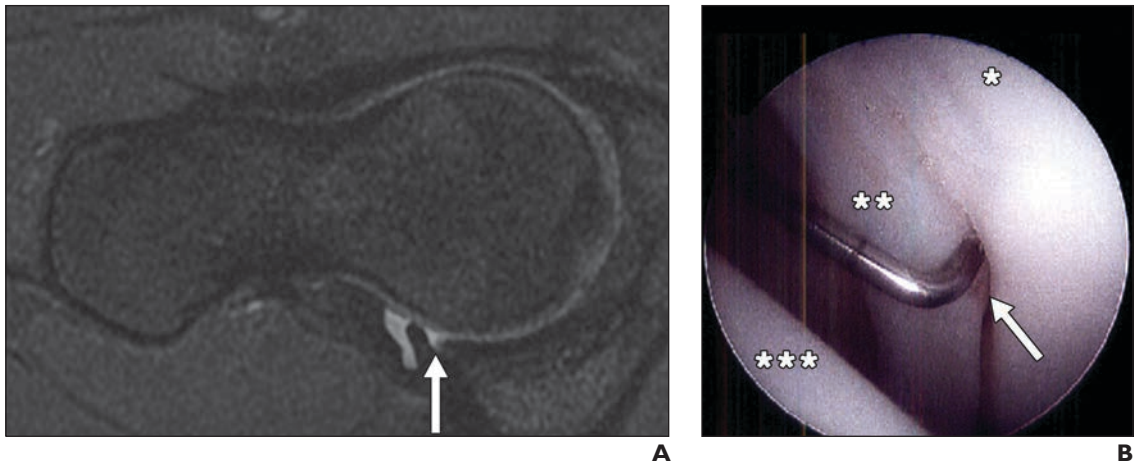


Fig. 6—17-year-old girl with posterosuperior sublabral sulcus.
A and **B,** Axial fat-saturated intermediate-weighted MR (**A**) and arthroscopic (**B**) images show posterosuperior sublabral sulcus (*arrow*), acetabulum (*single asterisk,* **B**), labrum (*double asterisks,* **B**), and femoral head (*triple asterisks,* **B**). Posterosuperior location is most common for sublabral sulcus. These sulci can be confused with posterior labral tears.

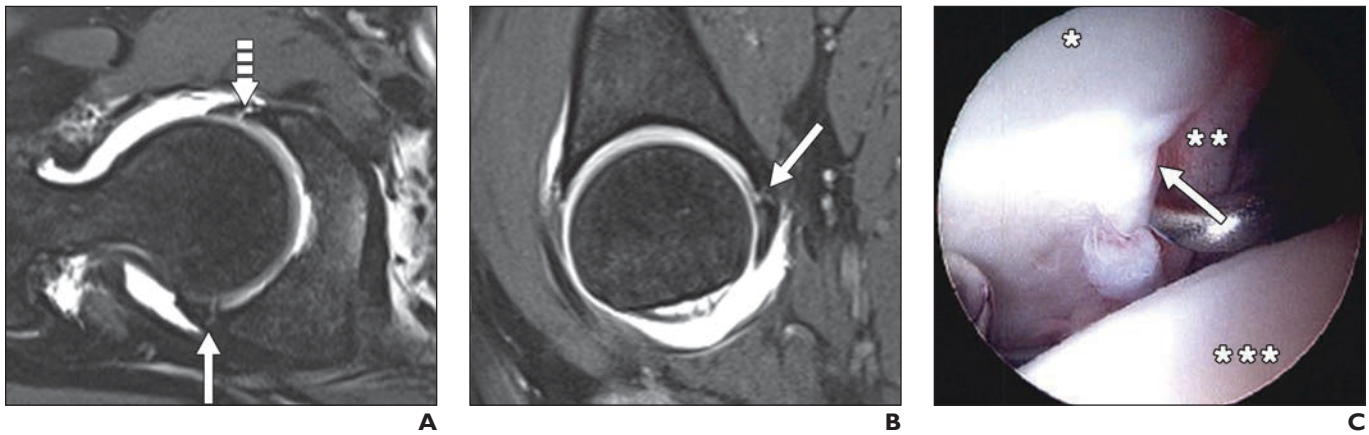


Fig. 7—52-year-old woman with posterior labral tear.
A–C, Axial intermediate-weighted (**A**) and sagittal T1-weighted (**B**) fat-saturated MR arthrographic and arthroscopic (**C**) images show posterior labral tear (*solid arrow*), acetabulum (*single asterisk,* **C**), labrum (*double asterisks,* **C**), and femoral head (*triple asterisks,* **C**). These findings can be confused with posterior sublabral sulci. Anterior labral tear (*dashed arrow,* **A**) also is evident.

Fig. 8—17-year-old boy with transverse ligament–labral junction sulcus. Coronal fat-saturated intermediate-weighted MR image shows transverse ligament–labral junction sulcus (*arrow*), which forms when transverse ligament intersects with acetabular labrum.

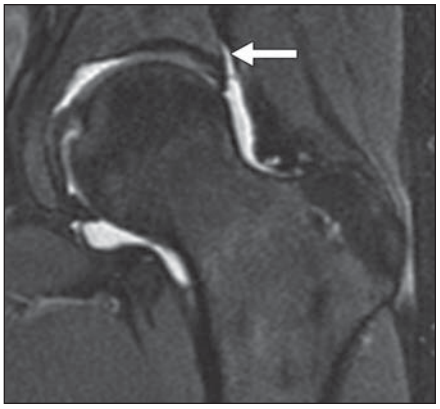
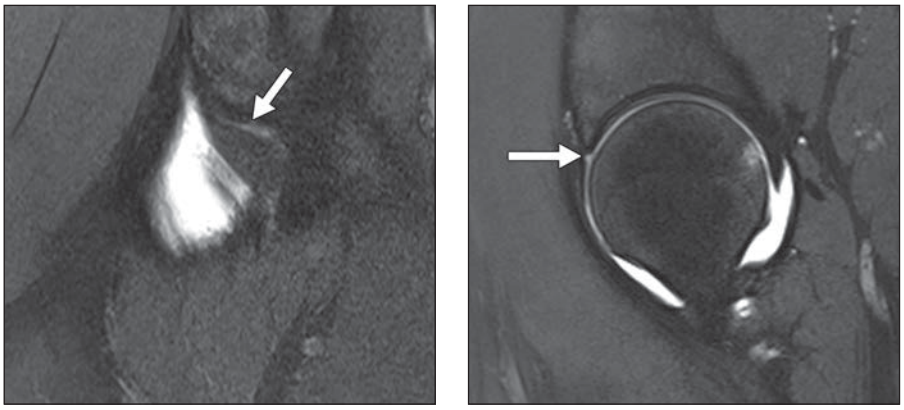


Fig. 9—42-year-old woman with perilabral sulcus. Coronal fat-saturated intermediate-weighted MR image shows perilabral sulcus (*arrow*), which is anatomic space created between joint capsule and labrum.



A **B**

Fig. 10—17-year-old boy with anterosuperior cleft.
A and **B,** Coronal (**A**) and sagittal (**B**) fat-saturated intermediate-weighted MR arthrographic images show anterosuperior cleft (*arrow*).

FOR YOUR INFORMATION

This article is available for CME/SAM credit. To access the examination for this article, follow the prompts.